NASA STTR 2004 Phase I Solicitation

T4 Goddard Space Flight Center

The mission of the Goddard Space Flight Center is to expand knowledge of the Earth and its environment, the solar system and the universe through observations from space. To assure that our nation maintains leadership in this endeavor, we are committed to excellence in scientific investigation, in the development and operation of space systems and in the advancement of essential technologies.

Subtopics

T4.01 Earth Science Sensors and Instruments

Lead Center: GSFC

The mission of the Earth Science Enterprise is to develop a scientific understanding of the Earth system and its responses to natural and human-induced changes to enable improved prediction of climate, weather, and natural hazards for present and future generations. By using breakthrough technologies from terrestrial applications, as well as the vantage point of space, we seek to observe, analyze, and model the Earth system to discover how it is changing and the consequences for life on Earth.

This STTR solicitation is to help provide advanced remote sensing technologies to enable future Earth and Lunar Science measurements.

Analytical Instrumentation for Planetary Atmospheres Research

Innovations and the application of new technologies are sought for improving the operating characteristics of gas chromatograph-mass spectrometer systems in harsh environments. Reductions in volume, weight, power, and cost while increases in performance, serviceability, and functionality of system components is highly desirable. The overall goal is to develop an instrument with increased performance in the areas of improved collection, detection, and measurement. Specific areas of interest include:

- Miniaturized and ruggedized gas chromatograph columns
- Microvalves
- Improved stability and performance of secondary electron multipliers
- Performance increases in the areas of size and conversion efficiency of high voltage DC/DC converters
- Rigid miniature vacuum pumps

Microwave Measurements Using Large Aperture Systems

New breakthrough technologies are sought for the construction of extremely large (tens of meters and larger diameter) microwave antenna systems. The systems must be compact upon launch, they must achieve high precision surface form factors, and they must include beam-scanning capabilities. The antenna compactness on launch can be achieved either through folding technologies or from some assemblage of small components into the larger final system in space. The microwave antenna surface characteristics must be accurate enough to produce microwave beam patterns with adequately small side lobes. The beam scanning must be facile and over many beam widths so as to enable cross-track scanning if in LEO, or scanning over the full globe if at GEO. The beam widths must be small enough to resolve the few kilometer scales needed for many geophysical observations. The microwave wavelengths will be determined according to the geophysical measurement of interest. The antenna concepts may include large single apertures or apertures composed of multiple elements that are operated synergistically to produce the desired performance.

Active Optical Systems and Technology for UAVs and Ballooncraft

Lidar remote sensing systems are required to meet the demanding requirements for future Earth Science missions. It is envisioned that lidar systems will be used in the following application areas: high spatial and temporal resolution observations of the land surface and vegetation cover (biomass); profiling of clouds, aerosols, and atmospheric state variables including temperature, humidity, winds, and trace constituents including tropospheric and stratospheric ozone and CO_2 (profiling and total column); measurement of the air/sea interface and mixed layer. New systems and approaches are sought in these areas, which will:

- Enable a new measurement capability;
- Enhance an existing measurement capability by significantly improving the performance (spatial/temporal resolution, accuracy, range of regard); and
- Substantially reduce the resources (cost, mass, volume, or power) required to attain the same measurement capability.

Systems and approaches will be considered that demonstrate a capability which is scalable to space or can be mounted on a relevant platform (UAV, long duration balloon, or aircraft) for calibration and validation of a space-borne system.

Unmanned Aerial Vehicle (UAV) Technologies for Remote Sensing

Avionics, real-time telemetry acquisition and remote sensing spectral imaging devices to support Unmanned Aerial Vehicles' (UAV) basic and applied science and application demonstrations (proposers need only to respond to a minimum of one of the below):

- Low cost avionics instrumentation for precise navigation and aircraft control, must have an attitude sampling rate greater than 25 Hz and an accuracy greater than 0.2° in roll and pitch.

- Real-time sensor fusion algorithms that combine low-cost inertial, GPS, magnetometer, and other sensor input to deliver aircraft state vectors at a rate greater than 50 Hz.

- Uncooled infrared and thermal spectral imager instrument to be less than 2 lbs and no larger than 0.05 m^3 in volume. Must operate autonomously in coordination with the onboard flight plan. It must have a built-in data acquisition system. The spectral bands must all be coregistered and the data must be GPS time tagged. Spectral bands should be centered at 3.75, 3.96, and 11microns as well as a band in the visible at 0.6 microns. Quantization bit resolution should be 10-bit minimum.

Ballooncraft Trajectory Control and Station-Keeping

Trajectory Control and Station-Keeping are critical items for future Ultra-Long Duration Balloon remote sensing concepts.

- Trajectory control would allow for some authority of the path of the system that may be required or desired for several reasons such as science mission, geopolitical, or improved recovery options. Activities include concept studies for alternative systems, propeller design and fabrication, functional flight testing, airship design and analysis, material development, and performance modeling.

T4.02 Space Science Sensors and Instruments

Lead Center: GSFC

Sensors and Instruments for space science applications are:

Analytical Instrumentation

Technical innovations are sought for sensitive, high precision, analog electronics for measurements of low voltages, currents, and temperatures. Work on cryogenic transition edge detection techniques for x-ray astronomy in particular, and IR sensors with high quantum efficiency. New robust, efficient integration techniques that are scalable to commercial manufacturing efforts are sought.

- High-resolution IR sensors with high quantum efficiency, especially novel ion-implanted silicon devices, and arrays. Sensitivities better than 10–16 W per root Hz.
- Cryogenic devices, such as SQUID amplifiers and SQUID multiplexers, superconducting transition-edge temperature sensors, and miniature, self-contained low-temperature He refrigerators.
- Analog application-specific integrated circuits (ASICS) with large dynamic range (> 105) and low power (< 100 microwatts per channel)
- Novel packaging techniques and interconnection techniques for analog and digital electronics

Optics

Larger telescopes in space (compared to the 6 m James Webb Space Telescope) demand lighter weight materials and new concepts, for example: designs including inflatable structures for lenses, mirrors, or antennas. Order of magnitude increases are envisioned. Applications of new materials could bring a new dimension to astronomy.

Goals for future NASA Optical Systems

	X-ray Mirrors	UV Mirrors	Visible Scanning	Lidar Telescope	NIR* Earth Science Systems	Far Infrared to submillimeter Wavelength
Energy Range	0.05–15 keV	100–400 nm	400–700 nm	355–2050 nm	0.7–4 mm	20–800 mm
Size	1–4 m	1–2 m	6–10+ m	0.7–1.5 m	3m–4 m	10–25 m
Areal Density	< 0.5 kg/m^2/grazing incidence	< 10 kg/m^2	2	< 10 kg/m^2	< 5 kg/m^2	< 5 kg/m^2
Surface Figure	l/150 at l = 633 nm	Diffraction Limited at l = 300 nm	l /150 at l = 500 nm	l/10 at l = 633 nm	l /75 at l = 1 mm	l /14 at l =20 mm

* Near-infrared

- Large-area, lightweight (2) focusing optics, including inflatable or deployable structures
- Novel laser devices (e.g., for lidars) that are tunable, compact, lower power and appropriate for mapping planetary (and lunar) surfaces. Future lidar systems may require up to ~1.5 m optics and novel designs.
- Fresnel-zone x-ray focusing optics to form large x-ray telescopes with small apertures, but high angular resolution, better than 1 milli-arc-second. Besides newly developed optics, these missions will require formation flying of spacecraft to an unprecedented level.

Mars and Lunar Initiative Technologies

The new Exploration Initiative (Code T) will embark upon an ambitious plan of robotic and human exploration of Mars, with intermediate work to be done on the moon. A broad program of analysis and resource identification is being planned, including x-ray and gamma-ray spectroscopy. Exploiting the existing resources will be an important part of these initiatives, rather than moving resources from place to place. These resource investigations will be conducted from orbit and from landers, both of which have differing requirements. On missions to Mars and other planets, instruments are typically limited to ~5–10 kg maximum.

- Low-weight, high throughput x-ray diffraction systems at 60 keV so that sample spectra can be accumulated in minutes or hours, not days.
- Laser-based x-ray generators (up to 60 keV), both compact and lightweight
- Improved scintillator resolution for gamma-rays up to 10 MeV
- High spatial resolution x-ray detectors, for producing ~50 meter or less maps from orbiting spacecraft, also with high throughput.

Computing

Massively parallel computer clusters for ever more complicated problems (in General Relativity, electrodynamics and “space weather,” for example) are becoming more important. Ways to increase performance and reliability– and lower cost –are called for.

- Novel computing techniques for simulations (including hydrodynamics, stellar evolution, general relativity calculations, etc.)

- New high-performance, low-cost, reliable massively-parallel computers (i.e., Beowulf clusters)
- Validation tools and software for space weather simulations and modeling

UAV and Balloon-craft Technologies

Both remotely piloted (unmanned airborne vehicles) and balloon instrumentation technologies are sought. New techniques and materials for forming “super-pressure” balloons, and ways of formation flying or station-keeping with balloons would enable new science from this inexpensive platform, especially in the unmanned exploration of other planets.

- Super-pressure balloon manufacturing technologies
- Station-keeping and trajectory control devices for balloons
- New architectures and technologies for remote sensing applications
- Trajectory simulation tools and software